



**MASSACHUSETTS
BAY
TRANSPORTATION
AUTHORITY**

TECHNICAL SPECIFICATION

EE&QA-962

Technical Specification for MBTA Green Line No. 8 Trailer Truck Drop Axle

ISSUED: September 14, 2023

REVISION: 1.1

EQUIPMENT ENGINEERING AND QUALITY ASSURANCE


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REVISION HISTORY

Revision Number	Revision Date	Revised Sections	Description, Reason for changes
1			Initial Draft
1.1	9/14/23	4.0	Updated Fatigue Test requirements



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1.0 PURPOSE

This Technical Specification details the requirements of the Massachusetts Bay Transportation Authority (MBTA), herein known as the Authority, for manufacture of Green Line Type 8 Light Rail Vehicle Trailer Truck Drop Axles.

2.0 DESCRIPTION OF ASSEMBLY

- 2.1 The Green Line Type 8 Light Rail Vehicles were manufactured by Ansaldo Breda for use on the MBTA's Green Line.
- 2.2 The vehicles are split into three sections, designated as the A-End, B-End and C (Center) Sections. The A- and B-end are equipped with Traction Motor powered trucks, while the Trailer Truck is located under the Center section and is non-powered. Most of the equipment is located on the roof of the vehicle. Further information can be found within the relevant maintenance manuals provided in Appendix 1.0C1.0C.
- 2.3 The trailer trucks utilize non-powered drop axles. The drop axle features a lowered crossbeam section and two spindle sections for mounting two individually rotating wheels. The drop axle is designed to facilitate low-floor passage between the wheels in the C section of the truck.
- 2.4 Section 4.0 describes the intended Technical Scope of Work for the drop axles.



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3.0 SCOPE OF SERVICES

3.1 General

- 3.1.1 The scope of this project is to manufacture new drop axles to replace existing drop axles on Type 8 Vehicle Center Trucks and provide performance and reliability consistent with an OEM drop axle. The work shall consist of fabrication, manufacture and testing in accordance with all applicable industry standards, codes, regulations, federal and state laws, OEM requirements, and the requirements of this Specification.
- 3.1.2 The Contractor shall work closely with the Authority to develop all manufacturing processes and technical documentation.
- 3.1.3 The Contractor shall furnish all engineering, testing, management, labor, materials, tools, incidentals, and all other items required to complete the specified work.
- 3.1.4 The Contractor shall be responsible for all logistics and costs associated with transportation between MBTA shops, the Contractor's facility, and any Subcontractors' facilities.
- 3.1.5 The Contractor shall be responsible for developing, procuring, maintaining, and calibrating all tools and test equipment necessary to ensure that the requirements of this Specification are met.
 - 3.1.5.1 Calibration requirements for measurement tools and test equipment are provided in Section 6.4.
 - 3.1.5.2 The Contractor shall not permit the destruction of any special tool or test equipment, such as drill jigs, welding fixtures, assembly fixtures, or test racks, without first offering the Authority the opportunity to acquire the same at no additional cost.
- 3.1.6 The Contractor shall perform all manufacturing work, inspections, and tests using written work instructions submitted to and approved by the Authority in accordance with Section 7.2 prior to starting any work.
 - 3.1.6.1 Work instructions must identify all tooling and test equipment used in the performance of the work.
 - 3.1.6.2 At a minimum, all tests and inspections required by the OEM documentation and this Specification must be performed. The Contractor shall be responsible for performing these tests and inspections as necessary to ensure proper interfaces and



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functionality of the drop axle.

3.1.7 Records must be kept of all inspection and testing results. The Contractor shall include all in-process inspections and tests, defined in Section 6.10.

3.1.7.1 The Contractor shall include all inspection and testing records in the Axle Procurement Book provided by the Contractor per Section 7.7.

3.1.8 The Contractor's quality control system shall adhere to the approved Project Quality Assurance Plan defined in Section 6.1.

3.1.8.1 The Contractor's quality control system shall ensure that all necessary operations are performed, properly documented, and verified by qualified quality control personnel at the time that the work is completed.

3.1.9 The manufactured drop axles shall be in compliance with the following documents, listed in order of precedence. All materials used for this Contract shall meet the flammability, smoke emission, and toxicity requirements provided in these documents.

3.1.9.1 Federal, State (Massachusetts), and Local codes and regulations.

3.1.9.2 The requirements of this Technical Specification.

3.1.9.3 OEM drawings, Illustrated Parts Catalogs, and Maintenance/Overhaul manuals, Appendix C.

3.1.9.4 Common Work Requirements, Appendix A

3.1.9.5 MBTA No. 8 Low Floor Car Technical Specifications, Conformed through CO12, Dated 12/2/2008, provided in Appendix D.

3.1.9.6 MBTA Specification EE&QA #770 Materials and Workmanship, provided in Appendix B.

3.1.9.7 Applicable industry standards and recommended practices proposed by the Contractor and approved by the Authority.

3.2 Manufacturing Requirements

3.2.1 The manufacture shall include the fabrication, assembly, testing, painting, and all other work required to produce a complete and functional drop axle meeting the requirements of this Specification.

3.2.2 Section 4.0 summarizes the scope of the manufacture of the drop axle. The



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following definitions are used throughout this Specification.

- 3.2.2.1 Design/Manufacture: Shall mean design, analysis, fabrication, installation, and testing of a new component/assembly. Authority approval is required for all design documentation, analysis and test procedures and reports, and installation procedures prior to commencing with the applicable task.
- 3.2.2.2 Inspect: Shall mean cleaning, inspection, painting, and related processes, such as measurements and tests, as defined in the Specification.
- 3.2.2.3 Test: Shall mean verification of the OEM functionality of a component/assembly by following evaluative procedures, as defined in the Specification.



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4.0 TECHNICAL SCOPE OF WORK

4.1 General Requirements

4.1.1 The drop axles shall be designed for normal revenue service use, subject to the Authority's standard maintenance practices and operating procedures.

4.1.2 Contractor Responsibilities

4.1.2.1 The Contractor shall be responsible for developing technical requirements for Authority review and approval where technical information, such as dimensions, tolerances, material, manufacturing/assembly process, heat treatment, finishing, corrosion protection, and inspection, are missing from the OEM drawings.

4.1.2.2 The Contractor may need to develop other technical information; the list above is not exhaustive.

4.1.2.3 The Authority does not certify or guarantee the accuracy of the OEM drawings or other documentation. The Contractor is responsible for confirming that the information provided in OEM drawings and documents is correct and reasonable for this application. The Contractor shall apply to the Authority in writing with any questions or concerns about the accuracy of information in the OEM drawings or documents and shall adhere to the Authority's written response.

4.1.2.4 The Authority is aware of errors in the conversion between metric and imperial units in the OEM drawings and documentation. The Contractor shall use the values provided in metric units unless the Contractor or Authority determine otherwise.



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4.2 Geometrical Characteristics

- 4.2.1 The axle shall be manufactured in accordance with the OEM drawing J36.2.54.100. The axle is composed of two spindles (J36.2.54.101) connected by means of two central crossbeams (J36.2.54.102).

4.3 Spindle Requirements

- 4.3.1 The spindle shall be a forged element composed of the 25 Cr Mo 4, quenched, and tempered. The steel must be fully killed to produce a fine grain structure (austenite grain size ≤ 5). The contractor can provide an equivalent alternative, but it must be approved by the Authority. The material shall achieve the following ranges:

4.3.1.1 Ultimate Tensile Strength: 590 – 790 N/mm²

4.3.1.2 Yield Strength: ≥ 440 N/mm² min

4.3.1.3 Impact Strength: ≥ 27 J at -30°C

- 4.3.2 The spindle shall be manufactured according to UNI EN 10083/1 (or approved equivalent material standard) with the following exceptions:

4.3.2.1 Hydrogen ≤ 2 ppm

4.3.2.2 Phosphorus-Sulfur $\leq 0.010\%$

- 4.3.3 The spindle forgings shall be heat treated to provide stress relief in accordance with the requirements listed within Section 1.10 of Appendix 1.0B following a rough machining of the forgings. The rough-machined spindle shall be within $\frac{1}{2}$ " of the final dimensions of the spindle.

4.3.3.1 The contractor shall provide a heat treatment process that shall be approved by the Authority. [CDRL 4.3.3.1]

4.3.3.2 The Contractor shall submit certification of all tempering and stress relief heat treatment processes. [CDRL 4.3.3.2]

- 4.3.4 Spindle Testing and Inspection Data

4.3.4.1 The contractor shall provide the following test and inspection data to the Authority:

4.3.4.1.1 Spindle Chemical Ladle Analysis of each heat. The chemical composition shall conform to the requirements listed in Sections 4.3.1 and 4.3.2. [CDRL 4.3.4.1.1]

4.3.4.1.2 Tension Test for each heat of forgings per the requirements within Sections 4.3.1. Test specimens shall be taken from



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the spindle after final stress relief heat treatment. The sample shall be taken from the forging at the time of rough machining. The specimen locations shall be approved by the Authority. [CDRL 4.3.4.1.2]

4.3.4.1.3 Impact Strength Test for each heat per the requirements within 4.3.1. Test specimens shall be taken from the spindle after final stress relief heat treatment. The sample shall be taken from the forging at the time of rough machining. [CDRL 4.3.4.1.3]

4.3.4.1.4 Ultrasonic testing shall be performed as per UNI 8572 Parts 1, 2 and 3 or other Authority approved criteria for each spindle assembly. The following criteria must be inspected, and the results provided to the Authority with each batch. [CDRL 4.3.4.1.4]

4.3.4.1.5 Axial (Longitudinal) Scanning of Spindle Stem

4.3.4.1.5.1 Reference standard with a flat bottom holes of 6 mm diameter.

4.3.4.1.5.2 The spindle shall be rejected if the amplitude of any discontinuity indication exceeds the indication levels obtained from the flat bottom holes.

4.3.4.1.5.3 Any discontinuity indication exceeding 10% of the indication level obtained from flat bottom holes shall be noted.

4.3.4.1.6 Radial (Transversal) Scanning of Spindle Stem

4.3.4.1.6.1 Reference standard with a flat bottom hole of 3 mm diameter.

4.3.4.1.6.2 The spindle shall be rejected if the amplitude of any discontinuity indication exceeds 50% of DAC curve obtained from the flat bottom holes.

4.3.4.1.6.3 The level of acceptability is raised to 75% of DAC curve in the central zone of the spindle stem (within diameter \leq 25% of end diameter)

4.3.4.1.7 Scanning on Spindle Head

4.3.4.1.7.1 Reference standard with a flat bottom hole of 3 mm diameter.



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4.3.4.1.7.2 Spindle shall be rejected in the amplitude of any discontinuity indication exceeds 50% of DAC curve obtained from the flat bottom holes.

4.4 Crossbeam Requirements

- 4.4.1 The crossbeam shall be machined from a solid bar of steel into the I-beam section shown in the OEM drawing J36.2.54.100. The steel must be fully killed to produce a fine grain structure (austenite grain size ≤ 5).
- 4.4.2 The crossbeam shall be composed of normalized FE 510 D1 UNI EN 10025 or another Authority approved standard.
- 4.4.3 The crossbeam must be heat treated to achieve the same mechanical properties as the spindle, as specified in Section 4.3.1. The contractor shall provide the chemical composition and mechanical properties data like Section 4.3.4.1 to the Authority. [CDRL 4.4.3]

4.5 Manufacturing of Axle

- 4.5.1 The axle shall be comprised of two (2) spindles and two (2) crossbeams that shall be welded together according to the Drawings specified in Section 4.2.1.
 - 4.5.1.1 The spindles and the crossbeams must be welded together to manufacture the finished axle. The connections shall achieve a heterogeneous weld between joints 20S and 21S.
 - 4.5.1.2 All welds must be qualified and prepared per requirements within Section 1.8 of Appendix A. The Contractor shall provide these weld procedures for Authority Approval [CDRL 4.5.1.2]
 - 4.5.1.2.1 The welding process must be approved and tested as per the following requirements on both the spindle and crossbeam:
 - 4.5.1.2.1.1 The welding specimens must be ultrasonically tested to check weld penetration per Section 1.14 of Appendix A. Reference standard with a flat bottom holes of 1.5 mm diameter. The axle shall be rejected if the amplitude of any discontinuity indication exceeds the indication levels obtained from the flat bottom holes. [CDRL 4.5.1.2.1.1]
 - 4.5.1.2.1.2 The welding specimens must be subject to impact testing, and shall achieve a minimum energy absorption of 27J at -30°C. The impact test shall be performed on both the weld



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metal area and the heat-affected zone. [CDRL 4.5.1.2.1.2]

4.5.1.3 All welders must be qualified per requirements within Section 1.8 of Appendix A. The Contractor shall provide these welder qualifications for Authority Approval [CDRL 4.5.1.3]

4.5.1.4 Upon completion of the welding, the axle shall undergo stress relief heat treatment per Section 1.10 of Appendix A. The contractor shall provide a stress relief heat treatment process that shall be approved by the Authority. [CDRL 4.5.1.4]

4.5.2 Weld Inspection and Testing

4.5.2.1 The welded joints of each axle shall be inspected by Dye Penetrant Testing or Mag particle Testing per Sections 1.1.2 or 1.1.3 of Appendix A to ensure that the weld is free of defects. This shall be performed following the root pass weld and each subsequent fill weld pass, ensuring that there are no defects in any weld pass. [CDRL 4.5.2.1]

4.5.2.1.1 Testing of each weld pass may be reduced upon approval by the Authority, if the Contractor demonstrates consistent welder skill, methods, and weld results for each weld. Reduced requirements of this test shall only apply to a single production run and shall not be applicable to future production runs of drop axles. This reduction is only applicable to the intermediate weld passes.

4.5.2.2 Ultrasonic Testing shall be performed as per UNI 8572 Parts 1, 2 and 3 or another Authority approved standard on the finished welds of each axle. The following criteria must be inspected, and the results provided to the Authority with each axle. This shall be performed following final surface grinding and stress relief heat treatment, ensuring that there are no defects on the weld surface. [CDRL 4.5.2.2]

4.5.2.2.1 Reference standard with flat bottom holes of 1.5 mm diameter.

4.5.2.2.2 The axle shall be rejected if the amplitude of any discontinuity indication exceeds the indication levels obtained from the flat bottom holes.

4.5.3 Fatigue Testing

4.5.3.1 The Contractor shall perform fatigue testing on the first drop



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axle specimen. The results of fatigue testing shall be provided to the Authority. [CDRL 4.5.3]

- 4.5.3.1.1 Fatigue tests shall be executed to verify the fatigue strength at 5 million cycles for pulsating bending exceeds 120 N/mm².
- 4.5.3.1.2 The specimen shall be ultrasonic or DPT tested upon completion of the fatigue testing.
- 4.5.3.1.3 This specimen shall not be utilized as a production piece and will be an additional piece, outside the specified quantity to be manufactured.
- 4.5.3.1.4 This test specimen shall be manufactured by qualified production welders.
- 4.5.3.1.5 This test piece shall be held until the Authority deems it acceptable to dispose.

4.5.4 Final Heat Machining

- 4.5.4.1 The final machining of the axles shall be performed following the final stress relief heat treatment of the welded axle assembly to achieve the required tolerances specified in OEM drawing J36.2.54.100.
- 4.5.4.2 Upon completion of final machining, the axle shall be DPT or Mag particle tested according to Appendix A Sections 1.1.2 or 1.1.3 to ensure no flaws are found.
- 4.5.4.3 Upon completion of final machining, the axle shall be inspected per OEM drawing J36.2.54.100.
- 4.5.4.4 Each axle shall be marked with a unique serial number on both spindle ends in accordance with OEM drawing J36.2.54.100.

4.6 Coatings

- 4.6.1 The axles shall be painted and/or have corrosion protection applied to the axle.
 - 4.6.1.1 The axle shall not be painted on the component mounting surface of the spindles. An Authority-approved corrosion protection product shall be applied during storage, packaging, and delivery of the axle.
 - 4.6.1.2 The non-mounting locations of the axle shall be painted in



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accordance with Section 1.11 of Appendix A or another
Authority-approved painting process.

4.7 Qualification and Acceptance Requirements

- 4.7.1 The Contractor shall meet all design requirements and provide documentation per Section 4.0 prior to any in service testing or First Article Inspection (FAI). All documentation must be approved by the MBTA prior to proceeding with an FAI and subsequent testing. [CDRL 4.7.1]
- 4.7.2 An FAI shall occur with one car set (2 (two) drop axles). The final inspection per Section 4.5.4 shall occur during this FAI. All requirements shall meet or exceed what is described in this specification.
- 4.7.3 After satisfactory preliminary FAI, the Contractor must submit a complete report for the Authority's approval. The Contractor must notify the Authority of any discrepancy, deviation, and failure from this Specification. Any correction procedure must be approved by the Authority before being implemented. [CDRL 4.7.3]
- 4.7.4 Two (2) manufactured drop axles shall be supplied to the Authority for installation and in-service acceptance testing. In-service acceptance testing shall last until at least at least 13,000 miles of service have been achieved and 1 year. After the 13,000 miles has been achieved, the Authority shall allow the Contractor to continue with production and installation. Any failures of the initial 2 axles during this time shall be considered a material defect and must be resolved as such.
- 4.7.5 After installing the 2 drop axles, the Authority will select the vehicles to complete the year of acceptance testing. Each of the sample drop axles will be visually monitored for damage throughout the year long period. After completing the in-service mileage for acceptance testing, the drop axles will be removed for visual and mag particle inspection and evaluation.
- 4.7.6 Upon successful completion of in-service acceptance testing stated in Sections 4.7.4 and 4.7.5, the Contactor will receive a formal letter of drop axle acceptance.



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5.0 COMMON WORK REQUIREMENTS

5.1 The Contractor shall review the attached Appendix A and provide the following CDRL documents:

- 5.1.1 Visual Inspection Procedure
- 5.1.2 Magnetic Particle Inspection Procedure
- 5.1.3 Dye Penetrant Inspection Procedure
- 5.1.4 Ultrasonic Inspection Procedure
- 5.1.5 WPS, PQR, and Welding Consumable Specifications
- 5.1.6 Furnace Heat Treatment Procedure
- 5.1.7 Corrosion Protection Plan
- 5.1.8 Cleaning and Stripping Plan

6.0 QUALITY AND CONFIGURATION REQUIREMENTS

6.1 Project Quality Assurance Plan (PQAP)

- 6.1.1 To provide a quality product to the Authority, the Contractor shall have planned and established a documented quality assurance program in compliance with ANSI/ISO/ASQ Q9001-2008 or latest revision, and FTA Quality Management System Guidelines, FTA-PA-27-5194-12-1.
- 6.1.2 The Contractor shall apply the principles of the appropriate ISO 9000 series processes or equivalent and enforce the elements of the quality assurance program within all parts of its organization and with all manufacturers, subcontractors, and suppliers performing Contract work.
- 6.1.3 Quality system documentation must be consistent with the skills needed, methods used, and training resident among personnel performing Contract work in accordance with the requirements of this Specification.
- 6.1.4 The Contractor shall submit for Authority review and approval its proposed Project Quality Assurance Plan (PQAP). [CDRL 6.1.4]
 - 6.1.4.1 This Plan must identify the controls, resources, and skills the Contractor will apply to satisfy project quality system requirements.
 - 6.1.4.2 For each specified quality system requirement, the Plan must identify how it will be satisfied, when, where, and by which job function.
 - 6.1.4.3 It must include a flow chart of the manufacturing sequence with



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all planned inspections, hold points, and customer witness points indicated. The chart shall indicate entities participating in the inspections.

6.1.4.4 Required inspection equipment, measurements, personnel certifications, workmanship acceptance standards, methods of inspection, and quality record documentation shall be identified in the PQAP.

6.1.4.5 The PQAP may refer to specific sections of other Contractor documents, such as the Quality Manual and supporting procedures, if such documents are applicable to this project. The Authority shall be notified of all customer witness point inspections and provided with an opportunity to witness these inspections. However, work may proceed beyond said inspection without written authorization from the Authority. The Authority reserves the right to institute at any time additional customer witness point inspections.

6.1.5 The Authority reserves the right to institute at any time customer-witnessed hold-point inspections. If customer-witnessed hold-point inspections are instituted, the Contractor may not proceed beyond said inspection prior to receiving written authorization from the Authority.

6.1.6 The Authority reserves the right to perform random in-process inspections.

6.2 Process Control

6.2.1 A significant part of the Contractor's quality program shall be to prevent problems by controlling the applicable manufacturing processes, thereby lessening the demands on required inspection and correction activities. To this end, the Contractor shall identify and plan processes necessary to produce, under controlled conditions, products, and services of the specified quality.

6.2.2 The Contractor shall prepare documented instructions and workmanship criteria and monitor and approve production processes.

6.2.3 Production equipment and processes must be maintained as necessary to ensure that products satisfy specified requirements.

6.3 Material Procurement and Control Plan

6.3.1 The Contractor and all Subcontractors shall establish and utilize procedures for control of components/assemblies provided by the Authority, manufactured by the Contractor or Subcontractor, or procured by the



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Contractor or Subcontractor.

6.3.2 The Contractor and all Subcontractors shall submit for Authority review and approval a Material Procurement and Control Plan defining procedures and processes that will be utilized by the Contractor and all Subcontractors for material procurement and control. [CDRL 6.3.2] At a minimum, the plan must identify procedures and processes for the following:

6.3.2.1 Configuration Control, to prevent purchase or use of incorrect or obsolete components/assemblies.

6.3.2.2 Material Availability, including base stock quantity, lead time, and re-order quantity for each component/assembly.

6.3.2.3 Receiving Tests or Inspections, to prevent use of defective material purchased or fabricated by the Contractor or Subcontractor. Acceptance criteria shall be identified for all tests or inspections.

6.3.2.3.1 Requirements must be provided for additional testing if nonconforming materials are identified.

6.3.2.4 Material Identification and Accountability, through all stages of the procurement process. Individual components/assemblies or lots shall retain unique identification and indicate their acceptance, rejection, or uninspected status.

6.3.2.5 Control and Disposition of Nonconforming Materials, to prevent inadvertent use or installation of defective components/assemblies.

6.3.3 Suppliers of nonconforming material shall be notified of the nonconformance, and the Contractor shall work with the Supplier or identify a new Supplier to prevent recurrence of the defect.

6.3.4 The Contractor shall establish a Material Review Board (MRB), comprised of qualified individuals, to review and dispose of nonconforming materials, recommend corrective actions to prevent recurrence of the defect, and verify that corrective actions have been implemented.

6.4 Control and Calibration of Measurement Tools and Test Equipment

6.4.1 Measurement tools and test equipment must be kept in current calibration over the length of the Contract. The Contractor and any Subcontractors shall establish and utilize control and calibration procedures to ensure that



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only calibrated measurement tools and test equipment are used.

- 6.4.1.1 The method and period of recalibration must be in accordance with a recognized national standard.
- 6.4.1.2 The Contractor and any Subcontractors shall keep on file a certification of calibration for all measurement tools and test equipment.
- 6.4.1.3 Calibration status, including calibration due date, must be marked on all measurement tools and test equipment.
- 6.4.1.4 Inspection and test records must include the identification and calibration status of all measurement tools and test equipment used.
- 6.4.1.5 Measurement tools and test equipment must be suitably stored to ensure continued accuracy and fitness for use.
- 6.4.2 Control and calibration procedures must contain provisions for determining the validity of previous measurements and tests and taking appropriate corrective action if measurement tools or test equipment are found out of calibration.
- 6.5 Inspection and Test Status
 - 6.5.1 The Contractor shall identify by suitable means the inspection and test status of products throughout the work process so that only acceptable parts are used. The Contractor's Project Quality Assurance Plan must identify the inspection authority responsible for releasing parts as conforming at each stage of the work.
- 6.6 Controlling Nonconforming Products and Services
 - 6.6.1 The Contractor shall establish and maintain a procedure to prevent the inadvertent use of nonconforming materials. Nonconforming materials must be segregated from acceptable items. In any case, the Contractor remains solely responsible to prevent unauthorized use of nonconforming material.
- 6.7 Corrective and Preventive Action
 - 6.7.1 The difference between *corrective* and *preventive* action must be clearly expressed in the Contractor's Project Quality Assurance Plan.
 - 6.7.1.1 Corrective Action procedures must address actual nonconformities that have occurred.



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- 6.7.1.2 Preventive Action procedures must address the potential for nonconformity to occur in the future.
 - 6.7.1.3 The Contractor shall establish and maintain procedures for taking corrective and preventive action that is appropriate to the size of the problems and commensurate with the risks that they present.
- 6.7.2 Corrective Action procedures must be effective in handling complaints from nonconformance reports and from all entities, including the MBTA. Methods must include problem analysis, recording results, determining the most effective corrective action, verifying that corrective actions have been taken, and that they are effective.
- 6.7.3 Preventive Action procedures must require use of all available information to eliminate potential sources of nonconformity. Methods must include data and information analysis, determining the best approaches to preventing nonconformity, implementing, and ensuring effectiveness of preventive action plans, and forwarding significant details of actions taken for review by management.
- 6.8 Use of Statistical Techniques
 - 6.8.1 Statistical quality control applications used in acceptance of parts, materials, or processes by the Contractor or its suppliers must be fully documented and based on generally recognized and accepted statistical quality control methods and defined in the Contractors Project Quality Assurance Plan.
- 6.9 Documentation
 - 6.9.1 All reports, plans, programs, procedures, schedules, and other materials prepared for the Contract work to be performed by the Contractor or any Subcontractors must be the property of the Authority. The Authority shall be entitled to copies and access to these materials during the progress of the Contract. All such reports, plans, programs, procedures, schedules, and other materials must be readily accessible to the Authority.
- 6.10 Inspection and Test Plan
 - 6.10.1 Inspection and testing are used as a means for the Contractor to demonstrate Specification compliance to the Authority. The Contractor shall submit an Inspection and Test Plan for review and approval by the Authority. [CDRL 6.10.1]
 - 6.10.1.1 The Inspection and Test Plan must include a comprehensive list



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of all inspection and testing to be performed during and after the manufacture of the drop axle, including references to the written inspection and test procedures.

- 6.10.1.2 The arrangement and content of Inspection and Test Procedures must be approved by the Authority as part of the Inspection and Test Plan.
- 6.10.2 The Contractor shall establish and maintain written procedures for inspection and testing activities, including requirements for feature, function, and performance verification/validation. All Inspection and Test procedures must be submitted to the Authority for review and approval. [CDRL 6.10.2]
 - 6.10.2.1 Procedures must identify all measurement tools and test equipment required to perform the inspection or test.
 - 6.10.2.2 Acceptance criteria must be identified for all inspections and tests.
- 6.10.3 Records must be kept of all inspection and testing results during and after manufacture of the drop axle to provide objective evidence that specified product requirements have been met. This includes all in-process inspections and tests, as well as the pre-shipment inspection and first article inspection. The arrangement and content of the record forms must be approved by the Authority as part of the Inspection and Test Plan.
 - 6.10.3.1 Records must include actual results of measurements taken and tests conducted.
 - 6.10.3.2 Inspection and test records must include the identification and calibration status of all measurement tools and test equipment used.
 - 6.10.3.3 Inspection and Test records must be included in the Axle Procurement Books, reference Section 7.7.
- 6.10.4 Pre-Shipment Inspection
 - 6.10.4.1 Prior to leaving the Contractor's facility, the manufactured drop axles must be properly prepared for shipping to ensure that no damage occurs during shipment.
 - 6.10.4.1.1 Any unit not properly covered and protected from damage will not be accepted by the Authority and will be returned to the Contractor for repair at no additional cost to the Authority.



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6.10.4.2 A pre-shipment inspection must be performed by the Contractor prior to shipping to confirm that all work has been completed, all components are included in the shipment, and all units have been appropriately prepared for shipping.

6.10.4.2.1 The Authority must be notified of the pre-shipment inspection and provided with an opportunity to witness the inspection.

6.10.4.3 A copy of the report must accompany the shipment and the original must be retained by the Contractor.

6.10.4.3.1 The report must include a description of the items included in the shipment and the identifying serial number(s) of each drop axle.

6.11 Handling and Shipment

6.11.1 The Contractor shall establish and provide a method for shipping and handling of the drop axle(s) to and from the Authority's facility. [CDRL 6.11.1]

6.11.1.1 This plan shall identify methods for preventing damage of the drop axle(s).

6.11.1.2 Secure storage must be ensured with an included documented receipt and dispatch.

6.11.1.3 This plan shall specify methods for packaging, packing, and marking.

6.11.1.4 Product quality following final inspection and testing must be preserved until delivered.

6.12 Nonconforming Material Report (NCR) and Corrective Action Plan (CAP)

6.12.1 Whenever repairs or replacements are required due to nonconforming materials identified by the Contractor, a nonconforming material report (NCR) must be prepared. The NCR shall reference the inspection record in which the nonconformance was identified and list the corrective and preventive actions taken as a result of the nonconformance.

6.12.1.1 Corrective actions must be taken for all nonconforming materials identified by the Contractor.

6.12.1.2 Preventive actions must be taken for all nonconforming materials resulting from the Contractor's or any Subcontractors' work procedures or processes.



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6.12.1.3 Multiple repairs or replacements performed on the same assembly may be grouped onto a single NCR in order to reduce the quantity of paperwork generated for each axle.

6.12.2 Templates for Nonconforming Material Reports must be submitted for Authority review and approval. [CDRL 6.12.2]

6.12.3 Templates for Corrective Action Plans must be submitted for Authority review and approval. [CDRL 6.12.3]

6.12.4 NCRs and CAPs must be included in the Axle Procurement Books required by Section 7.7.

7.0 CONTRACT REQUIREMENTS AND MANAGEMENT

7.1 Drop Axle Submittal Schedule

7.1.1 An initial submittal, including the items listed below, must be provided to the Authority within thirty (30) calendar days of Notice to Proceed (NTP).

7.1.1.1 Project Quality Assurance Plan [CDRL 6.1.4]

7.1.1.2 Material Procurement and Control Plan [CDRL 6.3.2]

7.1.1.3 Inspection and Test Plan [CDRL 6.10.1]

7.1.1.4 NCR Template [CDRL 6.12.2]

7.1.1.5 CAP Template [CDRL 6.12.3]

7.1.1.6 Program Management and Repair Plan [CDRL 7.2.1]

7.1.1.7 Correspondence Management Plan [CDRL 7.3.1]

7.1.1.8 Monthly Progress Report Template [CDRL 7.5.1]

7.1.1.9 Master Program Schedule [CDRL 7.6.1]

7.1.1.10 Axle Procurement Book Template [CDRL 7.7.1]

7.1.2 Components/assemblies that are expected to have a long lead time must be identified in the first technical submittal.

7.2 Program Management and Procurement Plan

7.2.1 The Contractor shall establish an organization to properly manage this Contract. The organization must be highly responsive to the needs of the Authority, as required by the Contract. The Contractor shall develop and submit a Program Management and Procurement Plan to the Authority for review and approval. [CDRL 7.2.1]

7.2.2 The Program Management and Procurement Plan must be updated and



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resubmitted at two (2) month intervals. The Program Management and Procurement Plan must describe all work required by this Specification and must include, but not necessarily be limited to:

- 7.2.2.1 A description of the Contractor's manufacturing methodology.
- 7.2.2.2 An Organization Chart identifying all key personnel for the Contractor and Subcontractors. The Organizational Chart must define and describe roles and responsibilities, reporting structure, key positions, personnel and their respective duties and responsibilities. Organizational charts must be revised, as required, for all phases of the Contract.
- 7.2.2.3 The internal methods and communications to be used to control the program schedule, technical performance, program changes, MRB corrective actions, subcontracts, purchase orders, material procurement, and field service support.
- 7.2.2.4 A flowchart of all project tasks, indicating task integration.
- 7.2.2.5 A Compliance Matrix identifying items that require Authority approval or are otherwise deliverable under the terms of this Contract. The Compliance Matrix must list the Contractor's document that demonstrates compliance with the requirement or deliverable, the status of the document, and a schedule showing when the document will be submitted or resubmitted to the Authority, unless already approved.
- 7.2.2.6 The Contractor's approach for developing work instructions, procedures, tooling, and inspection gages used to perform and control work within the scope of this Contract.
- 7.2.2.7 A list of all anticipated Work Procedures that will be used for performing work within the scope of this Contract. The arrangement and content of the work procedures must be approved by the Authority as part of the Program Management and Procurement Plan.
- 7.2.2.8 A Bill of Materials listing all components/assemblies used to complete all work within the scope of this Contract.
- 7.2.2.9 The name and scope of work for all Subcontractors that will be used under this Contract. Subcontractors are subject to Authority review and approval.
- 7.2.2.10 The Contractor shall submit all Program Work Procedures to the



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Authority for review and approval prior to beginning work.
[CDRL 7.2.2.9]

7.3 Correspondence Management Plan

- 7.3.1 The Contractor shall develop, maintain, utilize, and distribute a Correspondence Management Plan, which must identify stakeholder information needs, distribution methods, and status reporting requirements (such as status meetings, progress reports, project presentations, etc.). The Correspondence Management Plan is subject to Authority review and approval. [CDRL 7.3.1]
- 7.3.2 The plan must ensure general awareness of the program requirements among the Contractor, its Subcontractors, and the Authority and must include provision to report program milestones against those expectations.

7.4 Progress Review Meetings

- 7.4.1 Progress Review Meetings must be scheduled and attended by the Contractor and as required, any Subcontractors on a monthly or as-needed basis to review progress of the project. Progress meetings must be used to summarize and review the Monthly Progress Reports [CDRL 7.5.1], written correspondence exchanged since the last meeting, and open action items.
- 7.4.2 Progress Meeting Agendas must address the topics to be discussed during the meeting and must be distributed by the Contractor a minimum of five (5) working days in advance of the scheduled Progress Review Meeting.
- 7.4.3 The Contractor's authorized technical representative(s) shall also attend Progress Review Meetings as required to discuss technical aspects of the project and to review comments on documents. The Contractor's technical representatives shall be familiar with detailed design issues to facilitate quick resolution through discussion with the Authority's technical representatives. When appropriate, technical meetings shall be conducted as extensions to the progress meetings.

7.5 Monthly Progress Report

- 7.5.1 The Contractor shall prepare and submit a Monthly Progress Report to the Authority. The progress report must use an Authority approved template and be the focal point for each Progress Review Meeting. [CDRL 7.5.1]
- 7.5.2 The report must describe the current overall status drop axle manufacture, any inspection, and test reports performed on the drop axle, as needed.
- 7.5.3 The report must analyze causes for reported delays and provide a plan and



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schedule for implementing appropriate corrective and preventive actions.

7.6 Master Program Schedule

- 7.6.1 The Contractor shall develop and maintain a Master Program Schedule (MPS) for drop axle manufacture. The program schedule must provide a graphical representation of the project and identify all milestones, activities, durations, dependencies, earliest and latest possible dates for accomplishing each milestone and activity, the shortest and longest permissible time span between each milestone and activity, and major and minor paths which are critical for accomplishment of program objectives. The Master Program Schedule is subject to Authority review and approval. [CDRL 7.6.1]
- 7.6.2 The MPS must be monitored and controlled by the Contractor's management team responsible for all management functions and be updated and submitted to the Authority at least monthly during the design and production phases of the Contract. To allow for program evaluation, the monthly updated schedule must display the program status and provide a comparison to the original schedule.

7.7 Axle Procurement Book

- 7.7.1 The Contractor shall provide an Axle Procurement Book for each delivered axle. The Axle Procurement Book template must be submitted for Authority review and approval. [CDRL 7.7.1]
- 7.7.2 Axle Procurement Book must be provided to the Authority at the delivery of the drop axle and contain all information required by this Specification, including:
 - 7.7.2.1 Serial Number of Axle.
 - 7.7.2.2 Certificate of Compliance, signed and dated, certifying that the axle meets the requirements of this Specification.
 - 7.7.2.3 Manufacturer, model, revision level, and serial number of all subcomponents
 - 7.7.2.4 Test and Inspection Records, including receiving inspection, pre-shipment inspection, and all other measurements or readings taken during repair.
 - 7.7.2.5 Work Checklists, demonstrating that all required work procedures have been completed.



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7.7.2.6 Nonconforming Material Reports, including all attachments.

7.7.2.7 Corrective Action Plans for all work performed outside of the scope of this Specification.

7.7.2.8 Other documents as may be required by the Authority.

7.8 Facility Audit

7.8.1 All work under this Specification must be performed at the Contractor's or Subcontractor's facilities. Facilities used by the Contractor or Subcontractors may be subject to audit and approval by the Authority prior to conducting work under this contract.

7.8.2 The Authority may elect at any time to perform an audit of those aspects of the Contractor's or Subcontractor's facilities or operations that are related to work performed under this Contract. Reasonable notice will be provided by the Authority in advance of an audit.

7.9 In-Plant Representative

7.9.1 The Authority may station its own inspector at the Contractor's facilities during the Contract. The inspector shall be authorized to inspect all work in-process, work completed, and materials furnished for this Contract. The inspector may take measurements, determine quality of work performed, and make periodic assessments of the Contractor's and Subcontractors' work.

7.9.2 The Contractor shall provide at its facility one workstation with lockable file storage.

7.9.3 The Contractor shall also provide access to telephones and high-speed internet access for Authority representative(s) to have direct access to the internet for connection to project websites and email, with sufficient capacity to exchange large project files, pictures, and drawings.

7.9.4 Upon request, the inspector shall have access to, and be provided with, copies of all drawings, diagrams, data, test procedures, quality records, reports and other information used in connection with the Contract. Any requested documents and information must be provided to the inspector immediately upon request. Delays associated with providing requested information are the responsibility of the Contractor.

7.9.5 The Contractor shall extend to the Authority and its representative(s) full cooperation and necessary facilities to permit the convenient inspection of all materials, work, and equipment supplied. There must be a suitable means and tools to inspect and test all parts and equipment at the



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Contractor's facility, including mechanical tests of the drop axle. The Authority's representatives must be permitted an agreed upon period of time to conduct each inspection.

7.10 Delivered Drop Axle Acceptance and Warranty

- 7.10.1 The Contractor will be notified in writing of any discrepancies identified during inspection of the drop axles and/or acceptance testing.
- 7.10.2 Conditional Acceptance will be provided by the Authority following successful acceptance testing. Following Conditional Acceptance, the drop axles will enter service and a 5-year warranty period will start, as defined in the Contract Documentation.
- 7.10.3 Final acceptance will be provided by the Authority at the completion of the warranty period and resolution of all warranty issues or actions, as approved by the Authority. Failures in service prior to final acceptance will be handled in accordance with the warranty requirements defined in the Contract Documentation.
- 7.10.4 Any Drop Axle failure in service during the warranty service shall result in a returned axle to the Contractor for a failure analysis. A report shall be provided to the report in within 30 days of the return of the equipment.
- 7.10.5 Any defects that occur within 10% of greater total quantity of the produced axles shall be considered a material defect. The Contractor shall be responsible to submit a corrective action plan to resolve these defects at no cost to the MBTA and pay all MBTA labor required to correct those still in warranty.
 - 7.10.5.1 A defect as described above can result, solely at the MBTA's option, result in a cancellation of the contract.



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8.0 CONTRACT DELIVERABLES (CDRL)

CDRL	Subject
4.3.3.1	Spindle Stress Relief Heat Treatment Procedure
4.3.3.2	Spindle Stress Relief Heat Treatment Certificate
4.3.4.1.1	Spindle Chemical Ladle Analysis Report
4.3.4.1.2	Spindle Casting Tension Test Report
4.3.4.1.3	Spindle Impact Strength Test Report
4.3.4.1.4	Spindle Ultrasonic Testing Test Report
4.4.3	Cross Beam Material Composition Certificate
4.5.1.2	Weld Qualification Procedures
4.5.1.2.1.1	Weld Specimen Ultrasonic Test Report
4.5.1.2.1.2	Weld Specimen Impact Test Report
4.5.1.3	Welder Qualification
4.5.1.4	Welded Drop Axle Stress Relief Heat Treatment Procedure
4.5.2.1	Dye Penetrant/ Magnetic Particle Testing Report
4.5.2.2	Final Weld Ultrasonic Testing Report
4.5.3	Fatigue Testing Report
4.7.1	FAI Documentation
4.7.3	FAI Completion Report
5.1.1	Visual Inspection Procedure
5.1.2	Magnetic Particle Inspection Procedure
5.1.3	Dye Penetrant Inspection Procedure
5.1.4	Ultrasonic Inspection Procedure
5.1.5	WPS, PQR, and Welding Consumable Specifications
5.1.6	Furnace Heat Treatment Procedure
5.1.7	Corrosion Protection Plan
5.1.8	Cleaning and Stripping Plan
6.1.4	Project Quality Assurance Plan (PQAP)
6.3.2	Material Procurement and Control Plan
6.10.1	Inspection and Test Plan
6.10.2	Inspection and Test Procedures
6.11.1	Shipping and Handling Plan
6.12.2	Templates for Nonconforming Material Reports
6.12.3	Templates for Corrective Action Plans



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7.2.1	Program Management and Repair Plan
7.2.2.9	Program Work Procedures
7.3.1	Correspondence Management Plan
7.5.1	Monthly Progress Report Template
7.6.1	Master Program Schedule
7.7.1	Axle Procurement Book Template



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9.0 APPENDICES

- A. Common Work Requirements
- B. Materials and Workmanship Requirements
- C. Drawings, Procedures, Manuals, Parts Catalogs
- D. Technical Specifications
- E. Definitions and Abbreviations

END OF DOCUMENT